

# High Ripple Current Loads

## Application Note

Considerations when using switchmode power supplies to drive high ripple current loads such as motors and switch mode converters.

For applications where there is a large ripple component in the load current (such as DC-AC inverter/DC-DC converter/DC motor loads), there are several unexpected (and undesirable) problems that can occur with source power supplies of the switchmode type.

The reason for this is that, unlike linear supplies, the power is delivered to the output storage capacitors in 'packets' at a regular rate (switching frequency). For a steady load, the converter supplies a predictable 'packet' that keeps the capacitor 'topped up' and a steady output is produced. This output capacitance must not be too large, however, for when it is desired to reduce the output voltage, this capacitance must discharge into the load, and under light load the slew rate can be quite long. Under pulse load conditions, however, this output capacitance will significantly discharge upon application of the pulse load current and it will take a short time for the control loop to increase the output of the converter to the new load requirement. Since the voltage on the output capacitor will have dropped, the converter would have to supply almost infinite current into the capacitance to bring it back to the set voltage. Since the converter output is current limited, recharge of the capacitance can take several cycles.

If the ripple element is more than about 5% of the DC current, the power supply can start to have over-current operating phenomena either in the output over-current detection and control system or in the primary over-current sense and control system.

If the pulse rate of the load is harmonically related to the power supply switching frequencies, instability can occur in the control loops.

High ripple currents can seriously over stress the output capacitors of the power supply and precipitate early failure.

The most practical solution to most of these problems is to provide sufficient low ESR external capacitance so that the power supply sees a steady DC load. To this end, one needs to provide capacitance that limits the ripple voltage to significantly less than 5% of the operating output voltage.

As a general rule of thumb, one can compute the needed capacitance from the peak output current and allowing, say, 2.5% of the operating output voltage as ripple; the duty cycle; and frequency of the load.

$$C = (t / 2.5\% V_{out}) \times I_{pk} = (40 \times t / V_{out}) \times I_{pk}$$

Where: C = farads

t = seconds

V = Volts

I = amperes

Generally, the capacitance will run between 1000uF and 10,000uF per amp of peak load current, with the higher needed at low output voltages and the lesser at higher output voltages.

It is very important that the capacitor be of a so called 'computer grade' which has a low ESR and can tolerate very high ripple currents. Typically it will be a screw terminal type, and it is essential that it be installed between the power supply and the load. Leads are run from the power supply output terminals to the capacitor terminals and a second set of leads run from the capacitor to the load, to force the current to flow through the capacitor terminals.